Environmental Optical Characterization in Support of Mine Counter Measures Operations for Kernal Blitz

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LONG-TERM GOALS

This effort is to support emerging electro-optical systems and diver operations that require predictive and on-scene assessments of the optical properties for MCM and NSW operations. The linkage of remote sensing and modeling efforts to provide the warfighter with a common tactical picture to assess the performance of systems and determine operational time is critical to mission success particularly in the littoral region. The movement towards getting the warfighter tactical information on a daily basis is a focus for this program. This information is combined with modeling output from resuspension models to provide a “better estimate” of diver visibility and electro-optical system performance that is transmitted in a timely fashion over secure lines to the warfighter in the for mission planning and use in on scene operations. Our goal is to provide the warfighter with a common optical environmental picture. This information can be integrated into Tactical Decision Aids that are being developed for the emerging MCM systems and EOD diver operations.

OBJECTIVES

The objective is to demonstrate to the warfighter that environmental information can be utilized for mission planning and is available in near-real time for MCM/NSW operations. The focus for this effort is the development of a web-based information system that can be transmitted over unclassified and classified communication links that can be used by the warfighter during the Kernal Blitz exercise. In addition, the optical properties are derived using physical based resuspension models for the very shallow water condition for the “near coastal” (0-100 feet water depth) regime. The goal is to forecast or observed the temporal and spatial changes in the optical properties. The third objective is to collect real-time data from a mooring with optical instrumentation, download the data daily, and then send derived optical properties back to the METOC officer in a timely fashion for diver visibility and autonomous vehicle camera visibility. Lastly interaction with field METOC officer is needed to show the impact of spatial and temporal changes in the optical field on proposed MCM and NSW operations. This will help establish a link in the product line and expected information that the warfighter requires.

APPROACH

To show the fleet that optical properties can assist in decision-making on-scene, and to show that the optical products can be utilized in a timely fashion, there were several parallel efforts in support of the

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14. ABSTRACT
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Fleet exercise Kernal Blitz (April 2001). There were four portions of this project that supported the Kernal Blitz exercise. These included the use of spatial information from SeaWiFS imagery, the prediction of shallow water optical properties from resuspension modeling, the delivery of camera and diver visibility information from a mooring using HOBILabs Inc., a-beta, and daily transmission of the information to the fleet using SIPRNET website. CMDR Ray Robichaud was aboard the USS Tawara to support on-scene assessment and interpretation of the products to the warfighter and to act as a liaison in the dissemination of the information.

We extended the demonstration of the use of SeaWiFS imagery for spatial coverage of the operational area. This involved processing and delivering to the warfighter a product that could be used in a timely fashion. This was a key advancement. Imagery for the Kernal Blitz area was obtained for the area from Santa Barbara, CA to San Diego, CA and processed using two special scripts developed to give diver visibility and lidar performance from beam attenuation and diffuse attenuation respectively. The user had the option to zoom into an area to get the local spatial operational products. There were several operational areas that were identified and the diver visibility at the surface and lidar penetration depths were calculated for each of these operational areas. This automation of the SeaWiFS processing allowed the imagery to automatically produce products that had operational relevance to the warfighter (i.e. diver visibility and lidar penetration). The products were to show how MCM forces could use the optical data to plan airborne search and detection of targets in a given area, and to use large-scale information to effectively plan the prosecution of the targets in diver operations. This information was available to the warfighter through classified and unclassified connections. Compositing of imagery was used to help remove cloud cover.

While useful for surface optical products, remote sensing imagery cannot support very shallow water coastal conditions with high resuspension or subsurface structure. The dynamic coastal regime challenge was overcome by combining ocean color and a dynamic resuspension model. The Littoral Sediment Optical Model (LSOM) developed by Dr. Timothy Keen and Dr. Robert Stavn was used to derive scattering at depth. The model uses SWAN and POM to provide the wave and current fields. The scattering was derived using algorithms developed by Dr. Haltrin (NRL Code 7333) and modified to give diver visibility (Dr. McBride, Planning Systems Inc.,). The algorithm uses the particle size distribution from the LSOM and calculates an attenuation coefficient. The horizontal diver visibility was calculated using 4.8/c (c=total attenuation at 532 nm). This value lies between the 4/c and 5.3/c that has been reported for underwater visibility (Duntley 1952; Davies-Colley XXX). The scattering values for background phytoplankton were derived from SeaWiFS imagery in nearby coastal waters. Although absorption is part of the total attenuation, data for the Oceanside, CA area have shown that the single scattering albedo for the coastal regime is about 0.83 which allowed us to estimate diver visibility from either scattering alone or with chlorophyll contribution from SeaWiFS imagery (Keen and McBride). The important contribution of the LSOM effort is in the forecasting of optical properties and the extension of the optical properties to the very shallow water.

Navy operations were supported on-scene with a mooring deployed by Woods Hole Oceanographic Institute. This mooring had three HOBILABS a-beta instruments positioned at 3, 27, and 54 meter depths (approximately 57 meters of water). The a-beta data was collected each hour and then transmitted daily to NRL for processing for the warfighter. The data was used to provide temporal data of local optical variability. In addition, Bluefin Robotics had a Light Scattering Sensor for which camera visibility estimates were desired to estimate performance and expected camera visibility. Using manufacturer's calibration curves and estimating scattering from quartz relative to formazin an estimate for camera visibility was derived. This algorithm was implemented by Bluefin Robotics

(Scott Wilcox), and Jeff Rish of NSWCDD, and used as a decision tool for long-term versus short-term deployments.

The key to the warfighter is providing the information in a form that he can understand, use effectively, and is timely. To accomplish this, a web page was created so that data could be accessed. There were both unclassified and classified sites that were updated routinely http://www7333.nrlssc.navy.mil/ocolor/Exercises/kernal_blitz2001/kbindex.html
The data on web page included products derived for each operational area from imagery (visibility and lidar penetration; broad area and zoom capabilities), numerical modeling forecasts (LSOM products at surface, mid-depth, and 1 meter from bottom; SWAN and surf products; MODAS POM results), and mooring time series data. CMDR Robichaud was on-scene to help the operators interpret the product information and to determine what information was valuable and useful in operations. Standard text format was used over the classified connection with GIF pictures.

WORK COMPLETED

Satellite imagery- SeaWiFS imagery was collected continuously from 1 March through 31 May with diver visibility and lidar penetration depths calculated automatically for each operational area as demonstration products. The data were processed within two hours of reception and products updated to the Kernal Blitz demonstration web site. Areas that corresponded to the operational areas were selected and statistics were calculated to give a "best represented visibility and lidar penetration" for that operational region. A temporal graph showed the previous surface visibility and lidar penetration so temporal trends could be quickly evaluated for possible degradation or improvement.

LSOM integration- A very important task was completed by Dr. Walt McBride working in collaboration with Dr. Tim Keen and included the integration of optical predictions into a resuspension model. The model is the Littoral Sediment Optical Model (LSOM). The particle size distribution obtained from the TRANS98 resuspension model is converted to scattering using extended Mie calculations made by Dr. Haltrin and Dr. Stavn. The particle size distribution was obtained as a function of depth and spatial location. The wave and current fields arising from SWAN and MODAS-POM respectively provided the physical forcing for LSOM. A two-dimensional plot of visibility for an n-by-n grid array was formed for several of the operational areas. The advantage of the LSOM technique is that a profile of visibility could be derived. In addition, the LSOM permitted the forecasting of diver visibility for the very shallow water as a function of time (out to 48 hours). The data that was displayed on the web page included diver visibility one meter from the surface, mid-depth, and one meter off the bottom. Since most of the EOD dives were near the bottom and in shallow regions, dive reports were used to evaluate the utility of this demonstration product.

Real time web page- The unclassified web site updated information on surface optical conditions as soon as it was available. The web site included area bathymetry, identification of know operational areas, satellite imagery and derived products, numerical modeling results and forecasts of wind, wave, and surf conditions, optical mooring temporal data, and optical forecasts from the Littoral Sediment Optical Model (LSOM). The home page shows an overall lidar penetration from imagery, the current field from MODAS, and the diver visibility inferred from LSOM. The web page also included links to the WHOI mooring data web site. The classified site included the same information, but in text format. This information was transferred via SPIRNET. Aboard the Tawara, CMDR Robichaud received the web page and showed the warfighter how the information could be used in tactical decisions and in determining diver visibility.

a-beta mooring and Bluefin Robotics scattering sensor- Diver visibility was also calculated for 3 depths (3, 27, and 55 m) using the a-beta. This data was compared to the satellite derived visibility (resuspension was not a factor at 55 meters so LSOM was not used). This information was utilized to help show the need for assimilation of all data types for the warfighter to get an accurate common tactical picture of the optical field. Bluefin robotics used a Light Scattering Sensor (Wetlabs Inc.,) from which estimates of camera visibility were estimated to help in deployment predictions.

RESULTS

The most significant result is that the EOD units being deployed saw significance in the product lines even though it was at a relative scale. These divers clearly wanted a tool and the information that was being provided over the web page but there were two key areas that were lacking. The first is that "training" is required so that the divers and customers know what is available. The second is an understanding by the research community that timely delivery and understanding mission requirements is needed to get a good demonstration product. The visibility product from the satellite imagery over-estimated visibility by nearly a factor of two. This was largely due to an incorrect algorithm and the fact that diver visibility at depth is more vital to EOD as opposed to visibility just under the surface. The satellite imagery was only valid for the deeper waters where diving operations were seldom conducted. The over-estimation is best demonstrated in figure one showing how the operational areas were areas with rapid transitions from good to moderate visibility as derived from SeaWiFS.

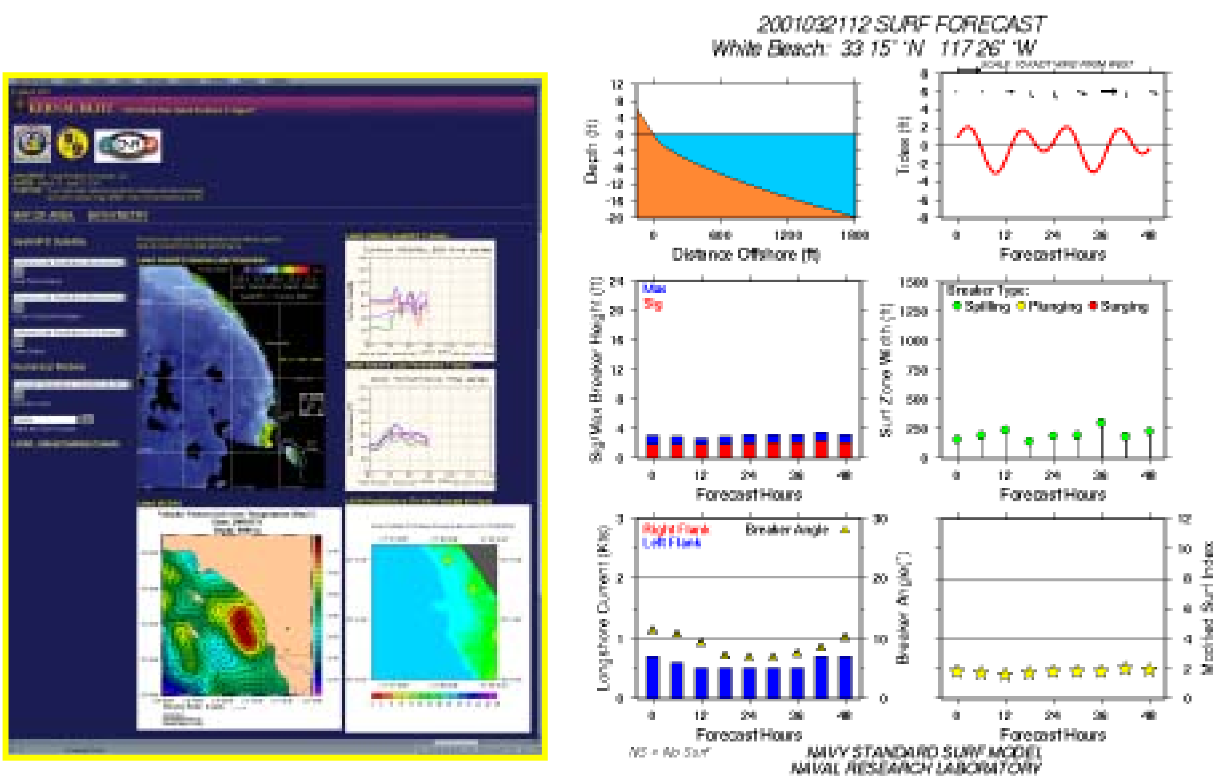

Figure 1: Kernal Blitz web page
[SeaWiFS imagery of lidar penetration depth, temporal visibility, current field, LSOM swimmer visibility midway through water column, and SURF forecasts are presented]

The advantage of having the LSOM model is demonstrated in figure two where the shift from forty-foot visibility to under twenty-foot visibility is rapid. On scene diver reports suggested that visibility was between 10 and 20 feet and consistent with the LSOM predictions although operations were very shallow. The SeaWiFS imagery suggested the visibility would be 60 feet or more but this was outside the area where diver operations were being conducted and where resuspension would cause degraded visibility.

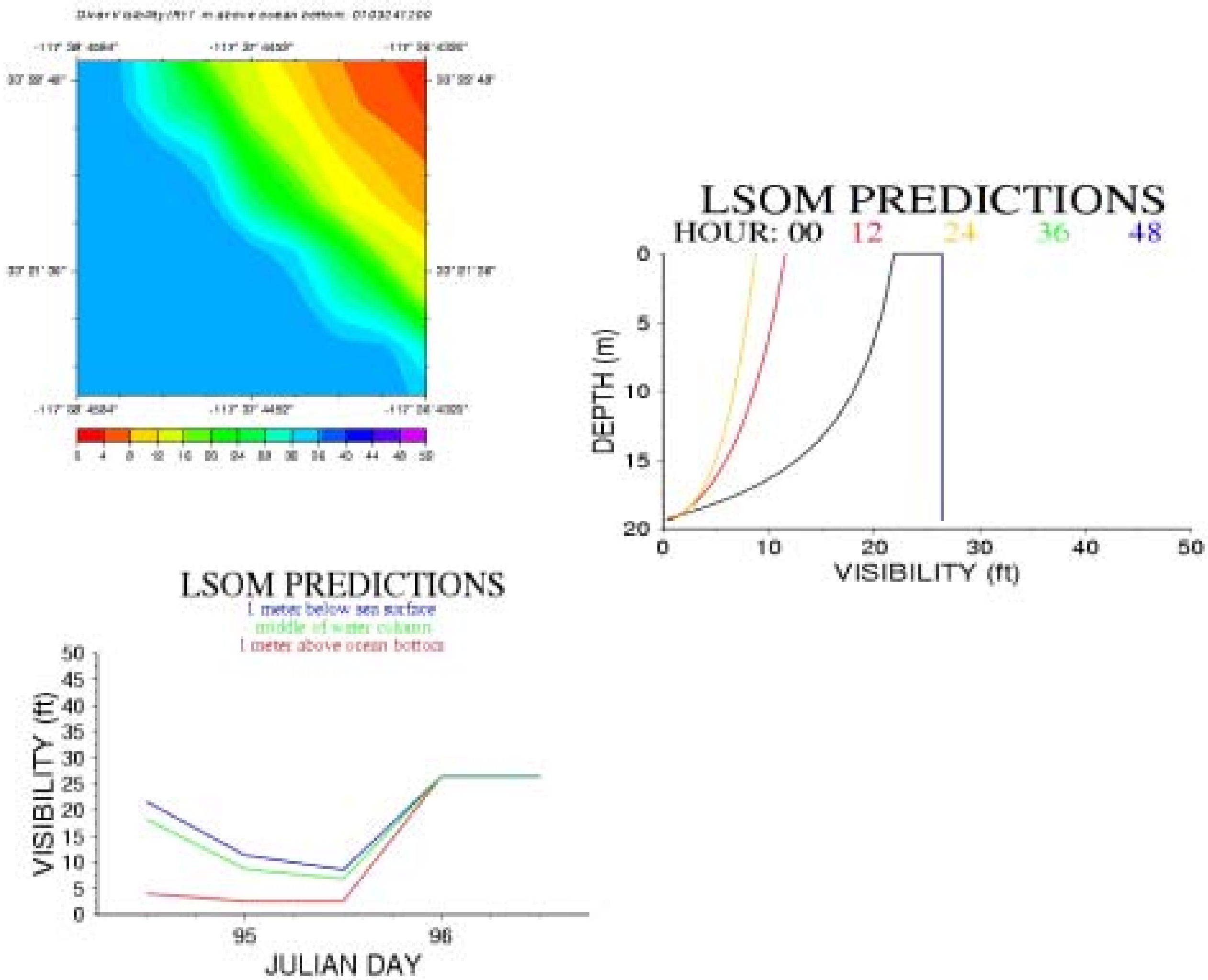

Figure 2: Littoral Sediment Optical Model Predictions of Diver Visibility
[Visibility prediction (in feet) one meter above the bottom; visibility over a 24 hour tidal cycle; and visibility predicted over 48 hours for surface, mid-depth and one meter from bottom]

The unclassified web page was available to the METOC command center located in San Diego for transmission to surface vessels. The classified web site was transmitted over the SPIRNET where CMDR Robichaud explained the trends in diver visibility degradation that were observed in the imagery or in the LSOM predictions. The LSOM predictions indicated a definite tidal cycle in the visibility predictions that the divers could use in mission planning. The predictions were validated by diver operations, the WHOI mooring, and the Bluefin Robotics AUV operations. The predicted camera visibility by the AUV was sufficiently close that operations were adjusted based on the small scattering sensor and the information on the web.

IMPACT/APPLICATIONS

The results of this demonstration showed to the divers that information about water clarity is available and can be used to help adjust their operations. The combined use of dynamic models, remote sensing, and visibility/lidar models showed that tactical decision aids can embed environmental data.

TRANSITIONS

The EOD units that participated in Kernal Blitz exercise encouraged the demonstration products and have indicated to CMDR Robichaud a willingness to endorse such products. The Warfighting Support Center at NAVOCEANO and COMMINEWARCOM (CMDR Berdeguez) also indicated that such products while useful, need to be incorporated through the SYSCOM and the tactics groups.

RELATED PROJECTS

-Common Tactical Picture (GRECE program), ONR f visibility algorithms are being developed under ONR funded Ocean Response Coastal Analysis System (ORCAS, Dr. P. Donaghay) and Evaluation of the a-Beta instrument and Distance Visibility Algorithm for camera and Diver Visibility (Weidemann)
-SPAWARS funds work with ocean color algorithms (R. Arnone POC)

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